

extensively for all types of constructional work, but it is now confined to a few special uses in industry where ductility and resistance to corrosion are required rather than high tensile strength.

It is these special characteristics, however, which make wrought iron eminently suitable for decorative iron work, for which it is still preferred by many blacksmiths. The texture of wrought iron improves with careful forging and it can be worked and welded into the most intricate, delicate and graceful shapes with greater ease than mild steel.

Wrought iron can be worked at a wider range of heat than is possible with mild steel so that despite its high cost, a small stock of wrought iron is particularly valuable for tricky jobs. For example, a small collar for welding onto a steel shank, is better made of wrought iron as it is able to withstand the extra heat which the collar naturally gets before the whole job is at the correct temperature for welding.

*Steel* is a general term applied to alloys of pure iron and carbon. The quality of steel is determined by the selection of iron and alloying ingredients used in its manufacture and not by its carbon content, or by the appearance of the fracture. The *temper* of steel refers to the carbon content and has nothing to do with quality. The term should not be confused with 'tempering', which is used in connection with the Heat Treatment described in Chapter 4. Detailed information on the tempering of carbon steels will be found in Balfour's 'Hints on Steel' listed at the end of the book (page 104).

### MILD STEEL

Mild steel which contains from 0·2 per cent to 0·3 per cent carbon, can be readily forged and welded within a narrower range of temperatures than wrought iron. It is less ductile and malleable than wrought iron but possesses greater tensile strength, which is an essential characteristic for the majority of forgings. It cannot be hardened or tempered and when fractured it shows a granular or non-fibrous structure.

### MEDIUM CARBON STEEL

Medium carbon steel contains from 0·5 per cent to 0·6 per cent carbon and is harder and stronger than mild steel, being readily forged but not so easily welded. While it cannot be tempered to hold a cutting edge, it can be hardened to a certain degree.

### HIGH CARBON STEEL

High carbon steel contains from 0·75 per cent to 1·5 per cent carbon and can be hardened to a high degree and tempered to retain a cutting edge.

When working high carbon steels in the forge, great care must be taken because they have a comparatively narrow range of forging and heat treatment temperatures, being easily oxidized or burnt beyond recovery. High carbon steel is usually graded into six tempers according to its carbon content. Various manufacturers have their own system of classification; the following is probably most common and is used by Arthur Balfour & Co. Ltd.

**Temper No. 5.** (0·875 per cent carbon) is the one most suitable for blacksmiths' and fitters' cutting tools, such as cold chisels, sets, etc.

**Temper No. 6.** (0·75 per cent carbon) is used for making hammer heads, hot sets, punches and drifts.

### ALLOY STEELS

Alloy steels include a great variety of steels containing, in addition to carbon, other constituents which give them special characteristics.

It is not within the scope of this book to describe the chemical contents or the physical and mechanical properties of the many types of steel and the student is recommended to read the special books on this subject which are listed on page 104.

*Note:* The word 'metal' is used throughout this book to denote either wrought iron or steel. If either is intended as distinct from the other, it is mentioned by name.

## PART II

## PART II

Part I described the blacksmith's shop with its equipment and tools, fuel and fire and the processes he uses in his work. The student is now ready to begin practical work; the first twelve lessons provide him with elementary exercises in smithing, which include simple forging and welding on light materials.

In every lesson the material to be used must be cut to the required length, and although metal of heavy section is not dealt with until later in the book, the instructions for cutting both light and heavy sections are given here.

### Cutting off cold metal of Light Section

Light section bars may be cut either with a cold chisel or over a hardie. It is not necessary to cut right through the bar. Nicks should be made evenly round the bar as shown in Fig. 33, so that the end may be easily dressed. The bar can then be snapped either by hammering it over the far side of the anvil as shown in Fig. 34, if the end is fairly short, or otherwise by striking the bar itself over the edge of the anvil. When cutting short lengths take care that the end does not fly up and hit you in the eye.



Fig. 33



Fig. 34

### Cutting off cold metal of Heavy Section

When cutting heavy sections use a cold set and sledge hammer; a striker will be needed and again, it is unnecessary to cut right through the bar; nicking all round is sufficient. This is shown in Fig. 35. If the bar is to be upset it is an advantage to dress the ends as shown in Fig. 36. This will prevent excess swelling at the tip and, by centralizing the force of the blow, reduce the tendency of the bar to buckle.



*Fig. 35*



*Fig. 36*



CHISEL END



SQUARE POINT



ROUND POINT

in  $\frac{1}{2}$ " Sq M/S

### HOLDING THE HAMMER

It needs practice to hit the metal in the right place.

Holding the hammer properly helps, so grip it like this near the end of the haft and swing the blow freely from the elbow *not* from the shoulder.

*Don't 'choke' the hammer by gripping it right under the head.*



### CHISEL END

Take a NEAR WELDING heat on the piece.

Hold it on the anvil face at a slight angle. Hammer it at a steeper angle towards the tongs. This will thin and spread the end.

*Don't try to push the metal with the hammer, hit it fair and square.*



After one or two blows turn the piece on its side, hold it flat on the anvil and correct the spreading.

Keep on forging first on the flat and then on the side, beginning at the tip and working backwards until it is finished.

### SQUARE POINT

The vital thing in forging a square point is a quick and accurate right angle turn of the wrist between blows.

Look at the hand holding the tongs, first this way—



D

Then like this—

Notice the quarter turn of the wrist.

Take a **LIGHT WELDING** heat each time the metal is re-heated so that any tendency to split is counteracted by the subsequent blows.



E

Draw to an abrupt point first, then work it backwards until the point is 3" long.

*Note:* When drawing heavy sections, work over the top of the bick, as this gives a fullering action, and draws the metal faster. (See Lesson 9 C.) Then finish the point on the flat of the anvil like this—



F

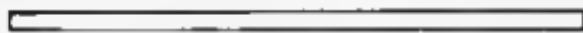
### ROUND POINT

To make a round point from either round or square bars, it is necessary to make a square point first. Then hammer in each corner to make the point eight-sided as shown here—

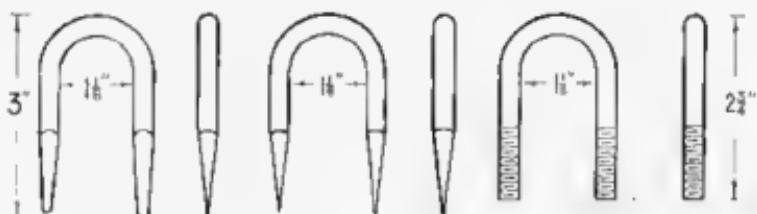
Next, round up the point.



G



Staple in  $\frac{5}{16}$ " Rd. M/S  
'U' Bolt in  $\frac{1}{2}$ " Rd. M/S



### CHAIN STAPLE

Cut off  $7\frac{1}{2}$ " of  $\frac{5}{16}$ " Rd. M.S.

Take a NEAR WELDING heat and draw down the points as shown in Lesson 1.

At a BRIGHT RED heat, start forming the bend around the back of the anvil, keeping the points in line.

Continue bending the piece like this to an even semi-circle, still keeping the points in line.

The beginner can test the radius on a piece of  $1\frac{1}{8}$ " diameter round bar to check his eye.

Finish like this—

Leave one point a little longer than the other as this helps to position the staple correctly when driving it into the wood.



### U-BOLT

Cut off 7" of  $\frac{1}{2}$ " Rd. M.S.

To make the U-bolt, first chamfer the ends like this—

Then bend to shape as with the staple.



D

Grip one end in the vice and twist the middle of the U so that the ends are nearly at right angles as shown here—



E

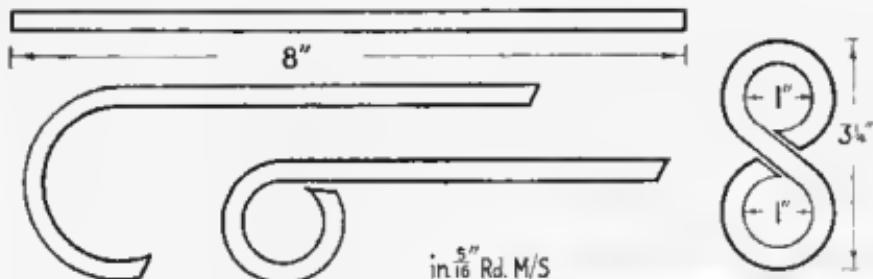
This allows room to rotate the die stock.



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Allow to cool before threading the ends.

Then twist it back into a U shape and true up with light hammer blows when the bolt is lying flat on the anvil face.



Take a **BRIGHT RED** heat and, holding the end of the bar flat on the anvil face, dress to a short bevel with the hammer like this—

The ends will then close snugly to the middle of the hook when the eyes are closed.

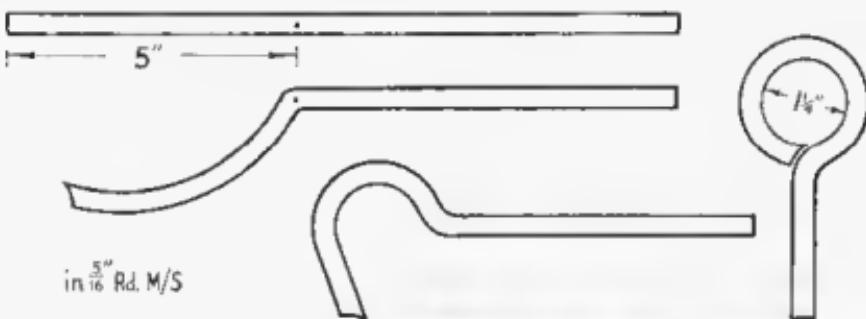
Start to form the first eye by striking the end over the bick like this and continue as in Lesson 2 B.

Repeat on the other end, but with the eye in the opposite direction.

This is the finished hook, with both eyes equal.

Test them over a piece of 1" diameter round bar and leave the hooks open as shown until the S hook is needed for use.





Mark off 5" from one end of the bar as shown in the drawing.

Take a BRIGHT RED heat and place the mark on the rounded edge of the anvil. The first blows with the hammer should be straight downwards and then at this angle—

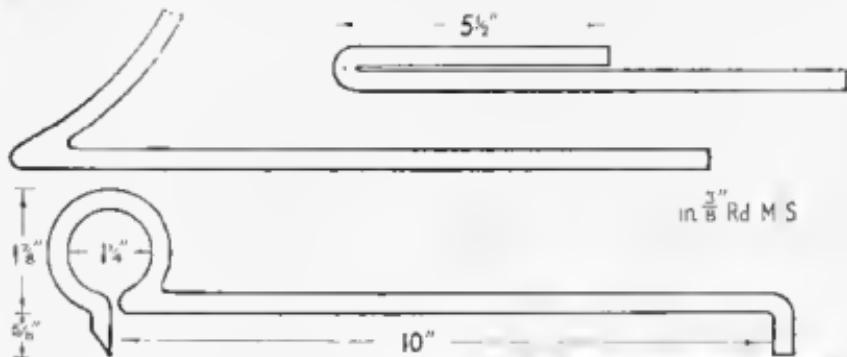
With each blow the free end will jerk upwards and start to form the bend for the eye.

Take another heat on the partly formed second bend. Cool out the first bend with water and continue to form eye like this—



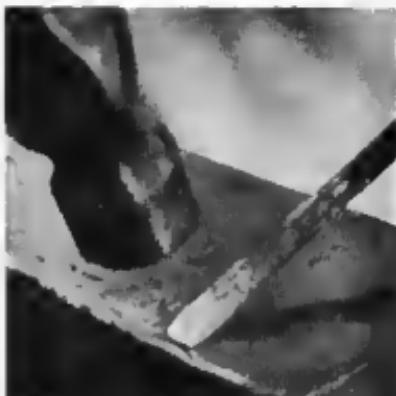
Finish the eye over the bick.

Close up by tapping lightly around the outside of the eye and test by trying it over a piece of  $1\frac{1}{8}$ " diameter round bar.



Before forming the eye, the acute bend at the root of the loop must be strengthened by adding extra metal in the form of a small wedge, made from  $\frac{1}{4}$ " round bar, welded into the rod.

At a BRIGHT RED heat, the wedge is first drawn to a chisel point so—



Next a dent must be made each side of the wedge to prevent it falling out while being welded, so at a NEAR WELDING heat, place the wedge end on the corner of the anvil and strike it with the hammer like this—



Lay the wedge end on the anvil table and cut off about  $\frac{1}{2}$ " with a hot chisel.



Mark the  $\frac{1}{8}$ " rod with a centre punch  $5\frac{1}{2}$ " from the end.

Take a NEAR WELDING heat and bend at this mark to a hairpin shape.

Force in the wedge and close the hairpin to grip it tightly.

Clean the fire and take a FULL WELDING heat. Hold the bar with the short leg of the hairpin standing up thus—

Weld in the wedge with moderate blows delivered at the angle shown.

Turn the hairpin flat and hammer in the sides.

Use a small hot chisel with a curved cutting edge to trim away the surplus metal leaving a neatly radiused corner.

This is much stronger than a rough and ragged edge as, with a smooth flowing curve, there is nothing to start a crack.

Take another heat on the short end and start to bend in over the bick like this—then turn it over as in Lesson 4 C to close the eye to the shape as shown in the next illustration, H.



D



E



F



G

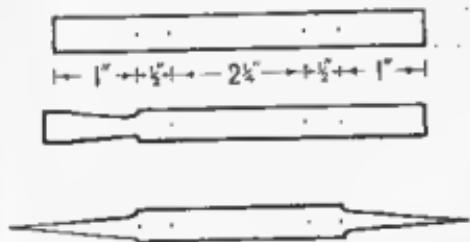
Here is the eye completed—

Flatten the end as shown in the drawing.

To complete the scribe, heat the other end, bend it to the dimensions given, like this—

And then cut off to match the point as shown in the drawing.





in  $\frac{1}{2} \times \frac{3}{16}$  Flat M/S

Cut off  $5\frac{1}{4}$ " from a piece of  $\frac{1}{2}'' \times \frac{3}{16}$ " flat, and mark it at 1" and  $1\frac{1}{2}$ " from each end.

Take a NEAR WELDING heat and with the punch mark nearest the end over the near edge of the anvil, forge a shoulder by striking with the heel of the hammer like this—

Draw the end to a point and then repeat on the other end.

To prevent the sharp edge of the vice jaw from galling or cracking the inside of the bends, use vice jaw clamps with rounded top edges.

Take a BRIGHT RED heat and grip in the vice with the second mark on the edge of the clamp. To make the corner as square as possible, first pull the end down with the tongs, leaving an arch so—



A



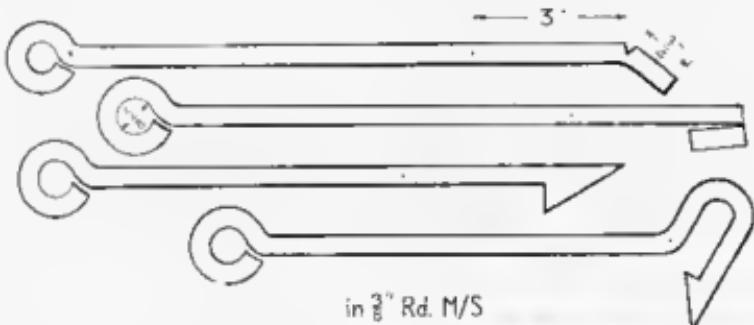
B



C

Next hammer the arch back towards the corner. In the picture the hammer is not only coming down but also moving bodily to the right. This is described as a drawing blow.

Heat the other end and repeat.



Take a piece of  $1"$  round mild steel  $10"$  long and bend one end into a tight eye with an inside diameter of  $\frac{1}{2}"$ .

Mark off  $3\frac{1}{2}"$  from the other end and, at a BRIGHT RED heat make a nick with a chisel  $\frac{1}{2}"$  from the end and double the end right back.

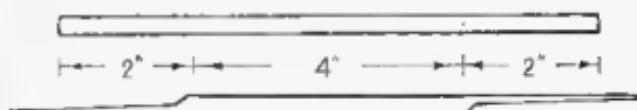
Take a FULL WELDING heat on the doubled end and weld with medium blows, drawing the tip to a chisel end. Leave the top shoulder of the barb sharp and square with both sides flat, like this—



This is the finished end.

Re-heat to BRIGHT RED and with the punch mark on the edge of the anvil, bend to a right angle with the head of the barb outside. To complete the hook, turn to a semi-circle as shown in the drawing.

Make sure that the hook and the eye are in line.



in  $\frac{5}{16}$ " Rd M/S.



Cut off 8" of  $\frac{5}{16}$ " Rd. and mark off at 2" from each end.

At a NEAR WELDING heat, draw the ends of the rod to blunt points.

Next using a bottom swage, forge each end to a half round section, as far as the punch mark.

At a BRIGHT RED heat, turn each end to exactly the same radius, so that they will pair up evenly when set together.

Re-heat if necessary, and bend the centre over the bick, leaving the ends matched up but  $\frac{1}{8}$ " apart.

When the split ends are closed together they should be very little thicker than the rest of the link.





in  $\frac{7}{8}$ " x  $\frac{1}{2}$ " Flat. M/S



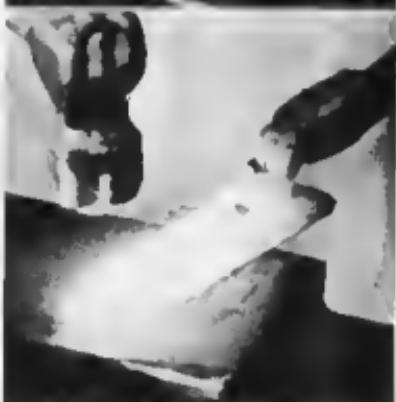
One end of the bar is first offset so that it may be held more conveniently in the tongs.

Take a **BRIGHT RED** heat, and double the bar back to a tight hairpin.



Clean the fire.

Take a **FULL WELDING** heat, lay the bar flat on the anvil face and weld with heavy blows, working from the bend backward to drive out clinker. Work quickly over the end and make sure the back is welded soundly. A second heat may be required.



Test the weld by drawing down to a long square point.

Metal of this size should first be forged over the anvil bick as the curved surface of the bick will tend to draw it length-wise. The drawing down will, consequently, be completed quickly as there will be little sideways spread.

In drawing down heavy sections, large fullers can be used instead of the anvil bick.



Finish the point by forging on the anvil face like this—

A defective weld will split while being drawn down.

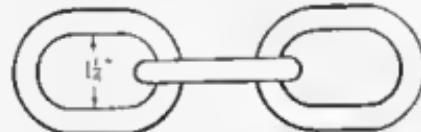
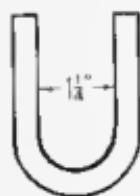


D

When cold, make a further test by dropping the point into a suitable hole in the swage block. Drive a wedge down between the unwelded parts and hammer them apart. A defective weld will open up as shown with the piece lying in the foreground.



E



in  $\frac{1}{8}$  Rd M/S or Wl Iron

From a piece of  $\frac{1}{2}$ " round cut off 6", and bend it to a U shape as in Lesson 2.

It may help a beginner who is inexperienced in fire welding to upset, or thicken, the end slightly before bending the U. (See Lessons 13 and 24.)

At a NEAR WELDING heat, draw out the scarf's cornerwise, like this—

Bend each end towards the other until the scarf's overlap, then set together ready to weld.

When joining or building up a chain, the completed links must be threaded over the unwelded link before setting the scarf's together.

Clean the fire.

Take a FULL WELDING heat and, with light blows, weld on top of the anvil, like this—

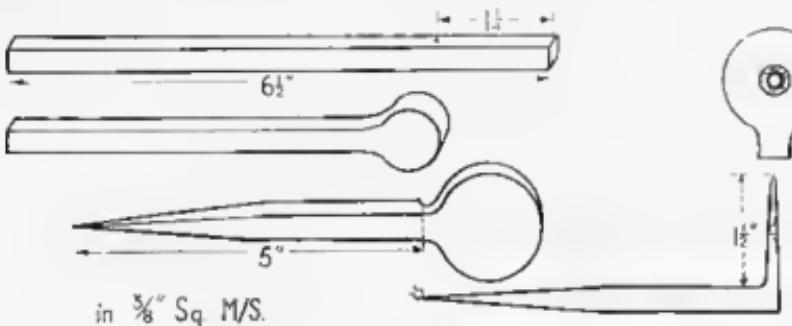


Work up on the bick, leaving the welds slightly larger than the original diameter of metal. This is shown in the weld on the top of the finished link hanging next to the tongs.

Lesson 10—*cont.*

Here are three finished chain links.





Take a  $\frac{3}{8}$ " square bar about 18" long and mark off  $6\frac{1}{2}"$ , but do not cut it. Take a NEAR WELDING heat on the end nearest the mark.

To produce a clean shoulder to the swelling quench by pouring water over the bar, thus confining the heat to the last  $1\frac{1}{2}"$ . Upset the end by driving the bar down on to the anvil until the end is as broad as it is long, i.e., about  $\frac{7}{8}$ " in each way.

Hold the bar level with the anvil top and forge in the corners with hammer blows, holding the hammer at an angle of  $45^\circ$ . Flatten the sides as you go.

Take a fresh heat if necessary and continue shaping up the knob with the shoulder over the rounded edge of the anvil. To keep a well defined shoulder to the knob, hold the left hand well below the level of the anvil face.



Give the bar a quarter of a turn and bring the hand level with the anvil top. With the knob only on the anvil face hammer it into an offset disc, the top side of which must be flush with the bar and the under side stepped to the part which will form the shank.

Next turn the disc on edge and, keeping it on the same part of the anvil, finish to a good shape by raising and lowering the bar as you strike like this—

When finished, the disc should be about  $1\frac{1}{2}$ " in diameter  $\times \frac{1}{8}$ " thick.

Do not bend the disc over yet or you will find it difficult to hold when drawing the point.

Take a **BRIGHT RED** heat at the mark on the bar, and cut off on the anvil table with a hot chisel. Take a second heat and, with the disc end held in the tongs, draw the other end down to a chisel point, slightly tapered on the sides like this—

With the step uppermost, bend the disc to a right angle over the rounded edge of the anvil, flattening the outside of the disc to the shoulder as shown in the drawing.



D



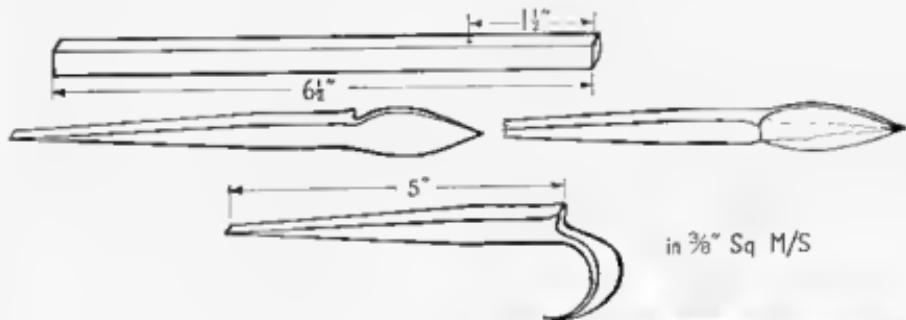
E



F



G



To form the bold shoulder which is required so that the clamp may be driven into the wall, take a NEAR WELDING heat and make a groove with a hand fuller at about 1 $\frac{1}{2}$ " from the end.



Using the same heat, draw the end to a fine square point and then flatten it back to the groove to form a shoulder.

The flattened end should look something like a spearhead 3" long with a rib down the middle.

Take a DULL RED heat and cut off to the required length. Holding the flattened end in the tongs take a NEAR WELDING heat and draw to a long chisel point. Then with the point in the tongs, finish the hook by bending the flattened part over the bick like this—

Test over a 1" bore pipe.